EASA European Union Aviation Safety Agency	**Means of Compliance with the Special Condition EHPS** **Teardown Inspection**	Doc. No. : **MOC-EHPS.450** Issue : 1 Date : 19 December 2024 Proposed ☒ Final ☐

The document at hand, Doc. No. MOC-EHPS.450, contains the 1st publication of the proposed Means of Compliance to the SC E-19 requirement EHPS.450 - Teardown Inspection.

All MOC publications of the SC E-19 will be consolidated in a single document in the Easy Access Rules (EAR) format for general convenience.

In this sense, the Statement of Issue and the structure of the document is the same for all of them.

Deadline to submit comments: 01 March 2025

Statement of Issue

EASA has received several requests for the type certification of electric engines and EHPS propulsion systems. In the absence of suitable certification specifications for the type certification of this type of product, a complete set of dedicated technical specifications in the form of a Special Condition for Electric/Hybrid Propulsion System was developed.

Specifically, the EHPS.10 requirement establishes the scope of application of the special condition, in which elements such as certified turbines and reciprocating engines or APUs having an ETSO could be reused in an EHPS.

The SC-E 19 design and safety objectives has been initiated from the CS-E while extracting the prescriptive text and therefore some paragraphs of the SC E-19 cover known technologies and designs of today's combustion engines and APUs.

In addition, the requirements of SC E 19 follow the approach previously used for the development of CS-23 Amendment 5, avoiding limiting technical innovation by describing prescriptive design solutions as certification standards.

The proposed Means Of Compliance (MOC) contained within this document fill this gap addressing the applicant's requests for clarification of EASA's interpretation of these objectives and of possibilities how to demonstrate compliance with them.

In this sense, the MOC included in this document may be updated with any necessary complement or modification, while additional MOC with different objectives in the Special Condition may also be incorporated in this document as necessary. During these revisions, EASA may recognise available Industry Standards as accepted SC E 19 Method of Compliance.

EASA may also accept other means to demonstrate compliance with the objectives contained in the Special Condition during the certification of a particular design. In doing so, EASA will thoroughly evaluate all MOC proposals and analyse their merits and associated justification. Subsequently EASA will establish whether the proposed MOC will ensure that the relevant safety objective in the Special Condition can be demonstrated as being fully met by it. The goal being to provide flexibility in the design of the EHPS whilst ensuring that the objectives of the Special Condition are satisfied and demonstrated by the applicant.

Structure of the document

The document provides clarifications of the rationale and intent of the SC- E 19 requirements referenced in the Scope of the document, as well as the links to other relevant requirements associated to these requirements.

For each specific relevant EHPS configuration (electric, reciprocating or turbine), one or more Means Of Compliance are then proposed.

When necessary, the document refers to Methods of Compliance, also defined as Level 3 MOC documents. The Method of Compliance can be parts or extracts from regulatory texts such as CS-E, FAR 33, AC guidance material, Certification Memo, Special Conditions, or Industry Standards.

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1 List of Acronyms

Acronym/Term	Definition
AMC	Acceptable Means of Compliance
APU	Auxiliary Power Unit
AC	Advisory Circular
CS	Certification Specification
EHPS	Electric Hybrid Propulsion System
FAR	Federal Aviation regulation
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
MOC	Means Of Compliance

2 References

[1] CS-E, amendment 7
[2] CS-APU, amendment 1
[3] SC E-19: Electric / Hybrid Propulsion System, issue 1
[4] EUROCAE ED-321 – Guidance Material for Endurance Substantiation of Electric/Hybrid Propulsion Systems (EHPS)
[5] [reserved]*
[6] AC 33.87-1A Engine Overtorque Test, Calibration Test, Endurance Test, and Teardown Inspection for Turbine Engine Certification
[7] IEEE Standard 43 Recommended Practice for testing Insulation Resistance of electric machinery
[8] IEC 60270 High Voltage test techniques – Partial discharge measurements

* to be updated when EUROCAE P-004 Guidance Material for Durability substantiation of Electric/Hybrid Propulsion Systems (EHPS) is published

3 Scope

This document proposes Means of Compliances (MOC) for EHPS.450 for electric engines.

It explains the purpose of the teardown inspection that needs to be performed after endurance and durability tests and which standards and methods of compliance are considered acceptable.

It provides info on acceptable pass/fail criteria and required data to establish performance data and deterioration effects.

Other elements of the EHPS propulsion system, such as the propulsion batteries and the distribution system, as well as their interaction with other regulations where necessary, are not included in the scope of this document.

Finally, the scope of this document includes the proposed Means of Compliance for those EHPS systems that include turbines or piston engines in hybrid-electric architectures.

The sections of the SC E 19 where no appropriate means to demonstrate compliance (ie. Industry Standard) has been published yet and consequently, there is no Method of Compliance associated, are tagged as “Reserved”.

4 Requirements

4.1 SC E-19

4.1.1 Requirements

The requirements to be considered within this MOC are provided in Reference [3]

- EHPS.450 Teardown Inspection

Additional requirements are related to this MOC:

- EHPS.420 Endurance Substantiation
- EHPS.430 Durability Substantiation
- EHPS.440 Calibration Assurance
- EHPS.480(c) Specific operation

The SC E-19 has been created having in mind that certified turbines and reciprocating engines or APU’s certified as ETSO could be installed within an EHPS.

The SC E-19 has been initiated from the CS-E while extracting, and therefore some paragraphs of the SC E-19 cover known technologies and designs of today’s combustion engines and APU’s.

4.1.2 EHPS.450 Teardown Inspection

The objective of EHPS.450 is to verify if the engine is still satisfactory for safe continued operation after completion of endurance and durability testing.

By comparing the condition before and after these tests, it supports the durability and reliability demonstration of the engine under extreme usages and the capability to still deliver the declared ratings after extreme usages.

4.1.3 Associated Interpretative Material / Means of Compliance of SC E-19

- CS-E 740(h)
- CS-E 440(c)
- ED-321 Guidance Material for Endurance Substantiation of Electric-Hybrid Propulsion
- AC 33.87-1A
- IEEE Standard 43 Recommended Practice for testing Insulation Resistance of electric machinery
- IEC 60270 High Voltage test techniques – Partial discharge measurements

4.2 CS-E

4.2.1 Link with CS-E 740(h) & CS-E 440(c)

CS-E is written with the intent to certify piston or gas turbine engines.
However, its content is important to understand the background and philosophy of the inspection criteria used for the demonstration of endurance and durability tests.

- CS-E 740(h) provides methods of Compliance on the Inspection Checks that needs to be performed after completion of the (endurance) test.

- AMC-E 740(h)(2) provides info on the level of engine disassembly necessary to verify component deterioration as it affects performance during the test. Therefore, the components condition after test, should be determined.

The distress seen resulting from the endurance and durability tests should not present the potential to create hazardous conditions. In addition to visible physical damage, non-visible damage should be assessed. Such damage may include but not necessarily be limited to insulation degradation, magnet demagnetization, etc. This overall evaluation should then be considered when defining and justifying the inspections and mandatory maintenance actions for instructions for continued airworthiness.

5 Means of compliance to EHPS.450 for *EHPS*

The objective of performing a teardown inspection after tests is to find evidence that demonstrates the EHPS is still safe for continued operation. The inspection also provides necessary information and confirmation on the condition of the EHPS after usage in service to be used for the maintenance program.

At the moment, endurance and durability test are considered different demonstrations, therefore the tear down inspection is covering different aspects. The two sections below propose methodologies that can be followed for the teardown inspection after each test.

5.1 Methodology for Endurance demonstration

5.1.1 ED-321

EUROCAE ED321, Chapter 9 provides a strategy and detailed Guidance on the post-test evaluation by performing a strip inspection of the EHPS and finding evidence that the EHPS is still safe for continued operation.

For the electrical engine, it provides checks to be performed to address potential concerns, based on the Critical Point Analysis and wear mechanisms identified during the endurance substantiation.

ED-321 Chapter 9 provides more detailed methods of compliance, specific for Electric Propulsion System, on performing the teardown / strip inspection. The ED-321 modifies the AC33.87-1A Appendix 11 to make it applicable for electric engine inspections. The AC 33.87-1A Chapter 4 and its appendices 11 and 12 can be used as a source for historical background and more detailed guidance for teardown inspections on turbine engines.

In some cases, it's not possible to perform a strip inspection (*e.g. assembly of parts glued together*) and degradation of electrical components is not always detectable through visual and dimensional inspection. ED-321 provides guidance on alternative ways to evaluate the system condition. It refers to industry standards for non-destructive testing of the function and deterioration of electric (engine) components and provides guidance on how to perform functional and performance checks to assess the condition of electrical components (e.g. magnets). Several examples are provided in the ED321.

ED-321 provides a summary of the expected information to be included in the certification test report.

5.1.1.1 IEEE 43 and IEC 60270

The ED321 chapter 9 request checking the condition of the insulation of an EHPS before and after endurance and durability tests are an important part of the teardown inspection. The IEEE standard 43 provides guidance on how to test the insulation resistance of the electric machinery. IEC 60270 provides acceptable methods and techniques on measuring partial discharge by High Voltage test.

5.1 Methodology for durability demonstration

5.1.1 ED P004

[reserved]

This EUROCAE Guidance Material follows a similar approach as defined by the Endurance Substantiation in ED-321. The outcome of the inspection will also be used to confirm the ICA and the related inspection, replacement and repair intervals.

Although the endurance and durability tests have a different purpose, the strategy for teardown inspection and pass/fail criteria can be used in a similar way, each with their own defined inspection criteria and pass/fail criteria.

6 Means of compliance to EHPS.450 for *turbine engines*

[Reserved]

7 Means of compliance to EHPS.450 for *piston engines*

[Reserved]

8 Means of compliance to EHPS.450 for *APUs*

[Reserved]